WO 01/25524

525 Rec'd PCT/PTO 20 NOV 2000

FORM PTO-1390 (REV 11-98)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER 540-248
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (If known, see 37 C F.R. 1 5) 09/700809
INTERNATIONAL APPLICATION NO. **PCT/GB00/03706**	INTERNATIONAL FILING DATE **27 September 2000**	PRIORITY DATE CLAIMED **30 September 1999**

TITLE OF INVENTION

AN IMAGING SYSTEM

APPLICANT(S) FOR DO/EO/US

JACK

OIPE JC68 NOV 20 2000 PATENT & TRADEMARK OFFICE

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has **NOT** expired.
   d. ☐ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. To 16. Below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information. **Copy of Request and three sheets formal drawings**
    ☐ This application is entitled to "Small entity" status. ☐ "Small entity" statement attached.

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U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
Unknown 09/700809	PCT/GB00/03706	540-248

17. ☒ The following fees are submitted: — CALCULATIONS — PTO USE ONLY

BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5):

-- Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $1000.00

-- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO...................$860.00

-- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO $710.00

-- International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) $690.00

-- International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4)......................................$100.00

					CALCULATIONS		PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =					$	860.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).					$	0.00	
CLAIMS	NUMBER FILED		NUMBER EXTRA	RATE			
Total Claims	15	-20 =	0	X $18.00	$	0.00	
Independent Claims	1	-3 =	0	X $80.00		0.00	
MULTIPLE DEPENDENT CLAIMS(S) (if applicable)				$270.00	$	0.00	
TOTAL OF ABOVE CALCULATIONS =					$	**860.00**	
Reduction by ½ for filing by small entity, if applicable. Small entity status must also be asserted. (Note 37 C.F.R. 1.9, 1.27, 1.28).						0.00	
SUBTOTAL =					$	**860.00**	
Processing fee of $130.00, for furnishing the English Translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(f)). +						0.00	
TOTAL NATIONAL FEE =					$	**860.00**	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). **$40.00** per property +					$	40.00	
Fee for Petition to Revive Unintentionally Abandoned Application ($1240.00 – Small Entity = $620.00)					$	0.00	
TOTAL FEES ENCLOSED =					$	**900.00**	
					Amount to be: refunded	$	
					Charged	$	

a. ☒ A check in the amount of $900.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. 14-1140 in the amount of $_____ to cover the above fees. A duplicate copy of this form is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 14-1140. A duplicate copy of this form is enclosed.

d. ☐ The entire content of the foreign application(s), referred to in this application is/are hereby incorporated by reference in this application.

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

NIXON & VANDERHYE P.C.
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SIGNATURE

Stanley C. Spooner
NAME

27,393 — REGISTRATION NUMBER
November 20, 2000 — Date

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

JACK Atty. Ref.: **540-248**

Serial No. **Unknown** Group:

National Phase of **PCT/GB00/03706**

Filed: **November 20, 2000** Examiner:

For: **AN IMAGING SYSTEM**

* * * * * * * * * * *

November 20, 2000

Assistant Commissioner for Patents
Washington, DC 20231

Sir:

PRELIMINARY AMENDMENT

Prior to calculation of the filing fee and in order to place the above identified application in better condition for examination, please amend the claims as follows:

IN THE CLAIMS

Claim 3, line 1, delete "or 2".

Claim 4, line 1, delete "or 3".

Claims 5, 6, 7, 8, 10, 11, 12, 13 and 14, line 1 of each, delete "any preceding claim" and insert -- Claim 1 --.

Claim 15, line 1, delete "or 14".

Cancel claim 16 without prejudice.

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REMARKS

The above amendments are made to place the claims in a more traditional format.

Respectfully submitted,

NIXON & VANDERHYE P.C.

By: ______________________

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AN IMAGING SYSTEM

The present invention relates to an imaging system and more particularly to an imaging system suitable for the detection and classification of objects or gases using spectral radiance.

Cameras, whether they be conventional TV type cameras or infra-red cameras typically rely on generating an image dependant on the received intensity of radiation. However in addition to intensity a point in object space can also be characterised by its spectral radiance and polarisation.

There are a number of devices which enable spectral radiance to be detected, one type being preferentially doped large scale focal plane (FPA) arrays. FPA's can be doped in a manner which enhances the spectral response of certain pixels and is fixed at manufacture. Typically columns of detector elements are doped to have identical and defined narrow spectral responses. Over the full width of the array several sets of columns are provided to cover the waveband of interest, such devices being manufactured to cover the three to five and eight to twelve micron bands. The detector array operates as a set of long linear arrays and is scanned across the image to collect data at all relevant sub-bands to form a complete image. This provides an output which is in effect a set of images at each of the wavelengths of the sub-bands.

A disadvantage of the above system is that it requires a mechanical scanning device which is expensive, requires a significant power supply, poses a reliability problem and also requires a housing of sufficient dimensions for the scanning mechanism, all of which may be undesirable in some applications, particularly military applications.

A second type of imager by which an image may be generated based on spectral radiance employs a filter wheel placed directly in front of a focal plane array or wide band camera. The filter wheel contains a number of filters each having a narrow sub-band transmission and these filters are placed in front of the detector in sequence to generate a series of separate images one for each sub-band. Again the use of a rotating filter wheel is not desirable and also with this system the image may require several cycles of the filter wheel to allow an integration to take place because the integration time for each sub-band will be short to ensure that the complete set of sub-bands is sampled in a short time compatible with a CCIR TV format (frame Rate 25Hz). With 10 or 12 sub-bands the time interval between separate sub-band samples is typically of the order of 0.5 of a second and is fixed. The time interval between separate samples through the sub-band is also long and fixed and the disadvantage of this is that the lack of flexibility prevents the sub-bands in which "contrast" or target discriminant has been detected being revisited more frequently.

A third imager type used in satellite applications employs an interferometric technique which is optimised for specific wavelengths and is subject to a set of

unique constraints related to operation in space where there is no vibration environment to cause misalignment (except at launch), no atmosphere attenuation within the instrument, and the interferometer is only likely to be scanned if a range of wavelengths are to be examined, otherwise it could be fixed or tuned.

According to the present invention there is provided an imaging system comprising an aperture for receiving radiation from object space, an interferometer arranged such that radiation received through the aperture is incident thereon, an array of detector elements for receiving output radiation from the interferometer, a controller arranged to scan the interferometer through a range of different path lengths and a processor for receiving signals from a plurality of elements of the array, the process determining a spectral radiance for each of a plurality of pixels, each pixel corresponding to one or more elements of the array, and generating image data, the grey scale of which is determined by the spectral radiance of each pixel.

By employing the present invention the spectral radiance, the wavelength of photons received by the imaging system, can be accurately determined to a resolution determined by the length of the interferometer arms but constrained to a reasonable value by typical size constraints appropriate to airborne military equipment. This may enable boundaries between objects to be detected which would not be possible using conventional broad band techniques. The data obtained may also be used to enable a material or gas to be identified from its unique spectral radiance characteristics permitting materials of particular interest to an observer to be flagged

up by subsequent processing techniques.

Preferably the processor performs a Fourier transform to ascertain the spectral radiance of each pixel, the spectral radiance of a plurality of pixels advantageously being determined simultaneously. This can be used to enable a real time image to be generated, and preferably the system further comprises an image generator generating an image in which the grey scale is dependant on the spectral radiance of each pixel. The grey scale image can be enhanced prior to being displayed as a colour image in accordance with known techniques.

Where the signal received from object space is weak then the interferometer is preferably scanned a plurality of times in order to enable spectral radiance of the pixels to be ascertained. Also depending on application it may be desirable to perform a non-uniform scan in the time domain with the interferometer to emphasise parts of the sub-band of special interest whilst suppressing parts with less interesting characteristics.

A non-uniform scan occurs when the length of a variable arm of the interferometer is increased in a non-linear manner by introduction, for example of a step function change in position.

In certain applications it is preferable to employ an interferometer which is a solid state device for this avoids the need for any moving parts associated with the

interferometer and may enable the complete imager to be a solid state device, a solid state device tending to be more reliable and rugged than a mechanical counterpart. To ensure against mis-alignment the optical elements of the interferometer may employ corner cubes as reflectors.

Where the interferometer is a solid state device it preferably comprises a material the refractive index of which may be changed by controlling an electric field across it, such materials being known as an electro-optic modulator, examples being Lithium Niobate and Galium Arsenide. The path length of one leg of the interferometer can be altered by the varying the refractive index of the material by any external means.

To assist in the detection of objects it is preferable that the processor performs an inter array comparison which is best carried out with the interferogram (rather than its Fourier Transform which is the spectral radiance) and a set of standard interferograms stored in a data base, by means of a standard real time correlator. This allocates to each pixel a specific spectral content partly in dependance on the spectral radiance of other pixels. The processor may perform a histogram manipulation according to standard techniques, on spectral radiance values and allocate a grey scale to each pixel in dependance on the number of pixels having a value in any one range in order to maximise grey scale contrast. Such a technique results in all pixels having a similar spectral radiance being assigned a certain grey scale value making any shape comprising those pixels easier to identify in a resultant image. Alternatively an equivalent technique would be to associate the histogram

with a range of colours and create a false colour image.

Advantageously the system may further comprise a polarimeter for receiving radiation from the same object space as radiation received by the interferometer, the processor combining data received from the polarimeter with that data received from the array of detector elements to obtain a score for each pixel. Similarly, or in addition to, the system may further comprise a camera for receiving radiation over the range of wavelengths of interest from the same object space as radiation is received by the interferometer. The output of the camera may then provide intensity data which is combined by the processor with that received from the said array of detector elements to obtain a score for each pixel. The data from the different sources is preferably combined by a fusion algorithm based on standard statistical techniques within the processor, the score attained representing the level of interest for a particular pixel. For example a particular pixel or group of pixels will score highly if the spectral radiance and/or polarisation and/or intensity is substantially different to that of adjacent pixels since such an event would imply an anomaly in target space that would be worth considering/investigating further.

One embodiment of the present invention will now be described by way of example with reference to the accompanying drawings of which:

Figures 1A and 1B illustrate an imaging system in accordance with the present invention;

Figure 2 is an exemplary spectral radiance plot for one particular pixel;

Figure 3 is a schematic representation of the data generated by the imaging system of Figures 1A and 1B.

Referring to Figure 1A an imaging system in accordance with the present invention comprises an aperture 1 for receiving an image from object space, represented by grid 2. Radiation received through the aperture 1 enters Michelson interferometer 3 where it is split into two optical paths by semi silvered optic 4. The first optical path passes through compensation element 5 to mirror 6 where it is reflected back through the compensation element 5, off the semi silvered surface of mirror 4 through collimator 7 to be incident on an array of the detector elements 8 at the focal plane.

The second optical path is reflected off the rear surface of semi silvered optic 4 to optical element 9. This comprises a material the refractive index of which is controlled by an applied electric field. Light passing through the material is reflected off the silvered rear surface back through the material and a change in the path length is introduced by progressively altering the applied voltage. This is equivalent to scanning a mirror through a distance Δx. The second optical path then passes through semi silvered optic 4 and is recombined with the first optical path such as to cause constructive and destructive interference depending on the relative phase of the light in the two optical paths.

The focal plane array comprises a two dimensional array of detector elements, each detector element (m,n) defining a pixel (m,n) corresponding to a region of object space represented by one square of grid 2. As the path length of one leg of the interferometer is varied by Δx the spectral radiance associated with each region of object space causes an interference pattern to be generated, such that the associated detector element (m,n) of the array detects a series of fringes passing across it, resulting from constructive and destructive interference of the two light paths within the Michelson interferometer 3. Thus the spectral radiance from object space corresponding to pixel (m,n), represented by graph A, generates an optical interferogram for pixel (m,n) where the intensity detected by the detector element is a function of Δx, as represented by graph B. This output for each pixel is received at the input X of a processor illustrated generally by the broken line 10 of Figure 1B.

Referring to now to Figure 1B, the function of the processor is schematically represented by the components contained within broken line 10. In practice the processor may be implemented by any suitable processing means, and may typically one or more micro processors which could be at separate locations. Also the processing may or may not be done in real time. The data received at input X could be received from a storage medium or directly from the focal plane array 8 as shown.

The processor of Figure 1B controls displacement Δx of mirror 9. The signal

received at X containing data from each element (m,n) of the display is first amplified by amplifier 11 and then converted to a digital signal by analogue to digital converter 12. A Fourier transform 13 is performed providing a spectral radiance for each pixel (m,n) as a function of Δx as indicated by graph C. A typical spectral radiance for an element (m,n) may be as illustrated in Figure 2. Referring again to Figure 1B the pixel spectral radiance for each element (m,n) is stored in data file 14. An intra-array comparison 15 is made of the data within data file 14 to identify pixels having similar values and also to set a limit for associating different pixels with the same spectral content, which limit is a function the noise level of the data and range of the data, in accordance with standard image processing techniques such as an adaptive convolution filter.

Each pixel is thus assigned a spectral data type which is stored in data file 16, the value being selected from one of a set comprising no more than, for example 256 which would match a conventional grey scale display. These values are then converted to a grey scale 17 on which a histogram optimisation is performed to maximise the contrast between the grey levels, before being transferred to frame store 19 prior to display on display 20.

In addition to receiving data from input X the processor 10 also receives inputs from a wide band camera 21 and polarimeter 22 both accurately aligned to view to the same object space, via lens apertures 23 and 24 respectively, such that the pixel output of both the camera and polarimeter correspond to that of the focal plane array 8 of Figure 1A.

From the output of the polarimeter 22 a pixel polarisation state data file 25 is generated on which data an intra-array comparison 26 is performed to assign a pixel polarisation type to each pixel, which type is stored in data file 27. This is converted to a grey scale, 28, on which histogram optimisation is performed, 29, and the resultant data stored in frame store 30 for display on the display 20. This enables an operator to switch between an image generated from the spectral radiance of a scene and an image generated from polarisation data of the same image. The operator may switch between images by manual intervention or the images may be fused to provide a composite image based on the key features of each image.

The output of camera 21 provides the intensity data for block 31. An intensity threshold is applied at 31 and the pixel intensity is stored in a data file 32.

From the output of block 31 a wide band pixel intensity data file 32 is generated. The content of this data file 32 together with the content of both the pixel polarisation type data file 27 and the pixel spectra type data file 16 is combined by fusion algorithm 33. This algorithm also receives an input from a spectral anomaly data file 34 the content of which is derived from the output of the intra-array comparator and limiter 15, any anomalies identified by the comparator and limiter above a predetermined threshold, 35, being stored in the spectral anomalies data file 34which contains a list of all pixels which have a spectral radiance different, as set by threshold 35, from the background and neighbouring pixels.

The fusion algorithm 33 processes the received data in accordance with parameters set by the user dependent on the application of the user. The fusion algorithm 33 will produce a score in data file 36 for each pixel, all scores above a threshold, 37, being identified by decision block 38 the output of which can be used either to the flag areas of interest on the display 20 or can identify areas of image which warrant further investigation. The fusion algorithm will produce a score dependent on the relative magnitude of each of the three inputs. A high score will result from a simultaneously measured spectral anomaly, polarisation anomaly and intensity anomaly.

Referring to Figure 3 there is illustrated a three dimensional hyper cube created from the data contained within the pixel spectral radiance data file 14 of Figure 1B. The x and y axis of the hyper cube represent the pixel position in object space, and wavelength is given along the z axis. For any one pixel the spectral radiance may be derived with respect to wavelength, and in the illustrated example three sections 40, 41, and 42 taken through the hyper cube are illustrated with average spectral radiance plots for each. Each spectral radiance plot can be compared with that for a known object, enabling the type of object or gas to be identified. Such a comparison process may be performed as a consequence of the output of decision block 38 determining that a particular pixel within the image is of interest.

The spectral radiance of typical scenarios will depend on the time of day and the

vegetation cover or nature of ground filling the field of a view of the instrument. This information is used to set the spectrometer resolution and other operating parameters. This is carried out in the processor. An average spectral radiance is calculated and compared with a small data set to establish the best match. This is used to set the operating parameters in a manner which will optimise the sensitivity of the instrument in the detection of anomalies.

The three dimensional hyper cube may be created for polarisation state or intensity as well as for spectral radiance. A five dimensional hyper cube can be created in a suitable mathematical form but cannot be represented in an easily comprehensible manner.

One embodiment of the present invention has been described above by way of example only. However it will be appreciated that the data obtained from the focal plane array 8 of Figure 1A can be processed in other ways whilst still within the scope of the appended claims.

CLAIMS

1. An imaging system comprising:

an aperture for receiving radiation from object space;

an interferometer arranged such that radiation received through the aperture is incident thereon;

an array of detector elements for receiving output radiation from the interferometer;

a controller arranged to scan the interferometer through a range of different path lengths; and

a processor for receiving signals from a plurality of elements of the array, determining a spectral radiance for each of a plurality of pixels, each pixel corresponding to one or more elements of the array, and generating an image, the grey scale of which is determined by the spectral radiance of each pixel.

2. A system as claimed in Claim 1 where in the array of detector elements is a two dimensional focal plane array.

3. A system as claimed in Claim 1 or 2 wherein the processor performs a Fourier transform to obtain the spectral radiance of each pixel.

4. A system as claimed in Claim 2 or 3 wherein the spectral radiance for a plurality of pixels is determined simultaneously.

5. A system as claimed in any preceding claim further comprising an image generator for generating an image in which the grey scale is dependent on the spectral radiance of each pixel.

6. A system as claimed in any preceding claim wherein the interferometer is scanned a plurality of times to obtain the spectral radiance of the pixels.

7. A system as claimed in any preceding claim wherein the interferometer scan is non uniform.

8. A system as claimed in any preceding claim wherein the interferometer is a solid state device.

9. A system as claimed in Claim 8 wherein the interferometer comprises a material the refractive index of which may be changed by controlling an electric field across it and wherein the path length of one leg of the interferometer is altered by varying the refractive index of the material.

10. A system as claimed in any preceding claim comprising a display and

wherein the spectral radiance data is processed to provide on the display a pseudo three dimensional cube with two perpendicular axes corresponding to the coordinates of the image and the third mutually perpendicular axis corresponding to wavelength of radiation received.

11. A system as claimed in any preceding claim wherein the processor performs an intra-array comparison and allocates each pixel a specific spectral content partly in dependance on the spectral radiance of other pixels.

12. A system as claimed in any preceding claim wherein the processor performs a histogram manipulation on the spectral radiance value and allocates a grey scale to each pixel in dependance the number of pixels having a value in any one range to maximise grey scale contrast.

13. A system as claimed in any preceding claim further comprising a polarimeter for receiving radiation from the same object space as radiation is received by the interferometer, the processor combining data received from the polarimeter with that received from said array of detector elements to obtain a score for each pixel.

14. A system as claimed in any preceding claim further comprising a camera for receiving radiation over the range of wavelengths of interest from the same object space as radiation is received by the interferometer, the output of the

camera providing intensity data which is combined by the processor with that received from the said array of detector elements to obtain a score for each pixel.

15. A system as claimed in Claim 13 or 14 wherein the data from the different sources is combined by a fusion algorithm contained within the processor.

16. An imaging system substantially as hereinbefore described with reference to and/or as illustrated in the accompanying Figures.

ABSTRACT

AN IMAGING SYSTEM

An imaging system is provided where radiation from object space (2) is incident on an array of detector elements (8) via an interferometer (3), the interferometer (3) being scanned such that the output of each pixel comprises an interferogram B generated from the radiation received from a corresponding region of object space (2), enabling image data to be generated in dependence on the output of the pixels, which image data is derived from the spectral radiance associated with each pixel.

Figure 1A

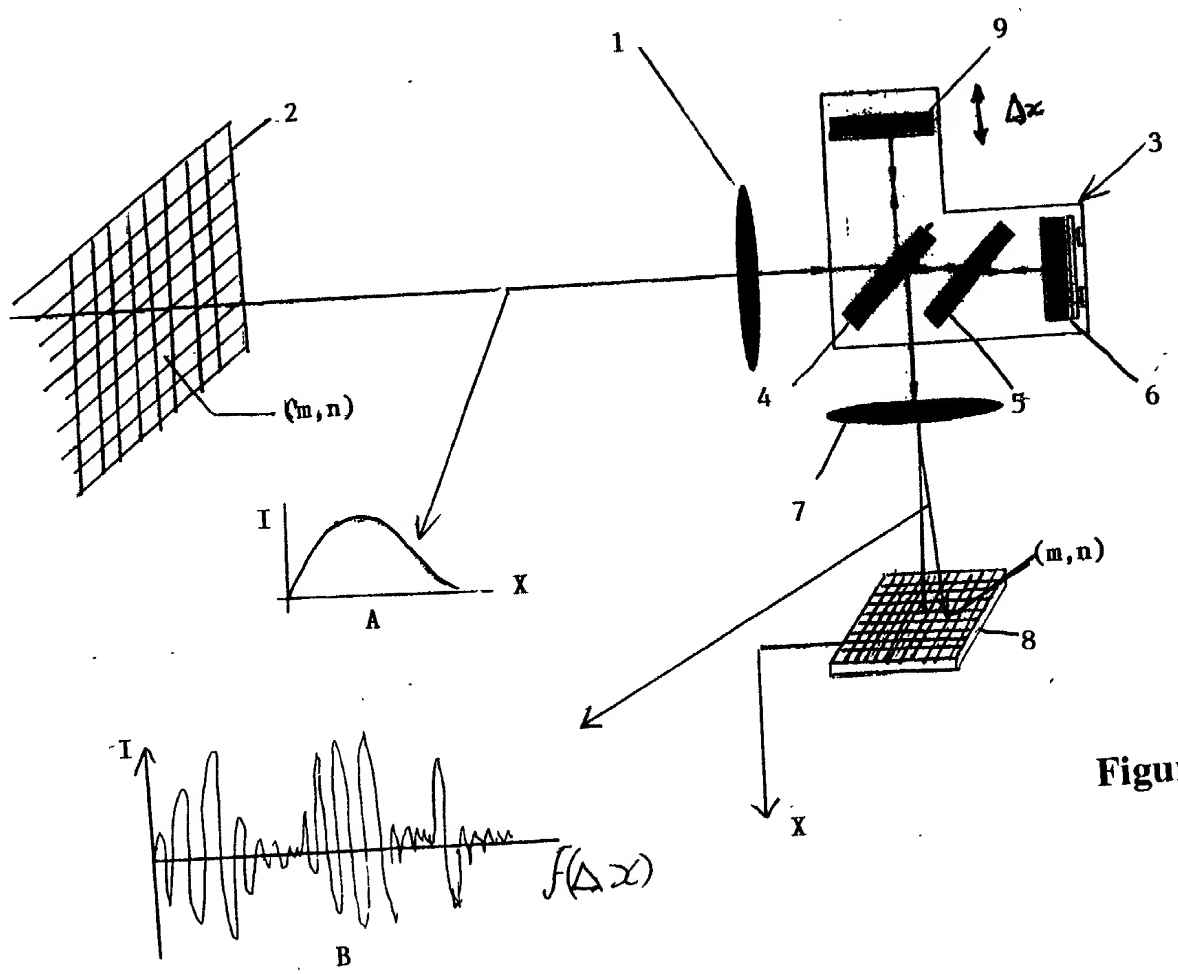

Figure 1A

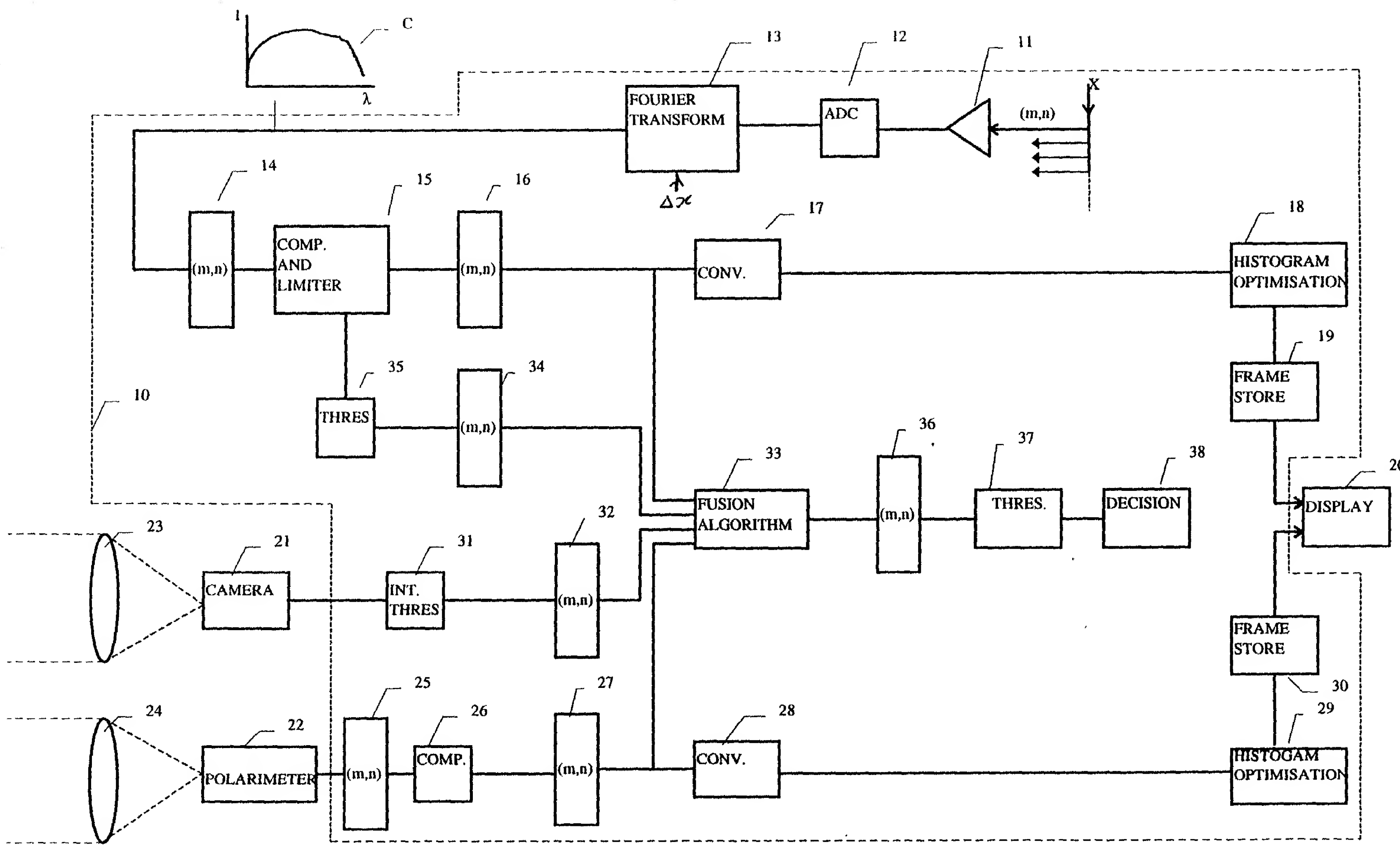

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Figure 1B

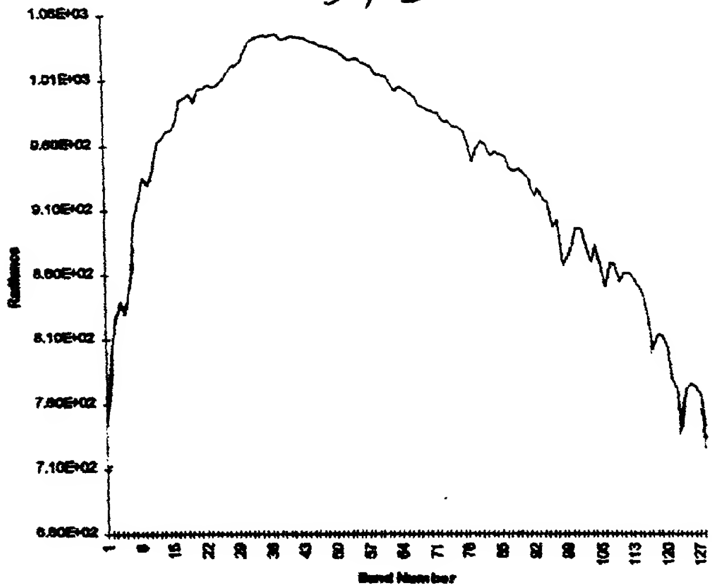

Figure 2

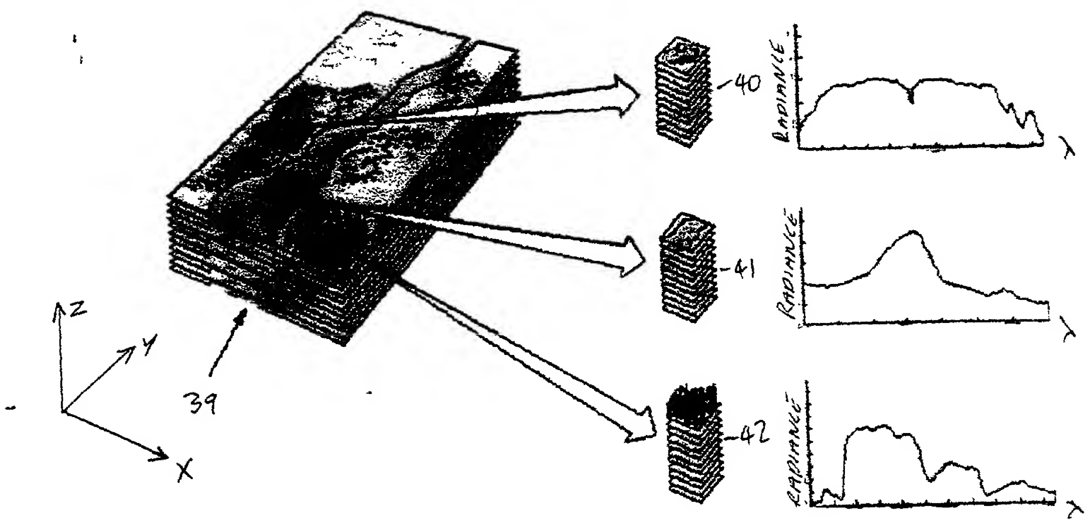

Figure 3

Nixon & Vanderhye P.C. (12/97)

RULE 63 (37 C.F.R. 1.63)
DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:
AN IMAGING SYSTEM
the specification of which (**check** applicable **box(s)**):

- [x] is attached hereto
- [ ] was filed on ______ as U.S. Application Serial No. ______
- [x] was filed as PCT International application No. PCT/GB/03706 on 27/09/2000

and (if applicable to U.S or PCT application) was amended on ______

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 C.F.R. 1.56. I hereby claim foreign priority benefits under 35 U.S.C. 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed or, if no priority is claimed, before the filing date of this application:
Priority Foreign Application(s):

Application Number	Country	Day/Month/Year Filed
9923013.8	GB	30/09/99

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States provisional application(s) listed below.

Application Number	Date/Month/Year Filed

I hereby claim the benefit under 35 U.S.C. 120/365 of all prior United States and PCT international applications listed above or below and, insofar as the subject matter of each of the claims of this application is not disclosed in such prior applications in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. 1.56 which occurred between the filing date of the prior applications and the national or PCT international filing date of this application:

Prior U.S./PCT Application(s): Application Serial No.	Day/Month/Year Filed	Status: patented pending, abandoned

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon. And I hereby appoint **NIXON & VANDERHYE P.C., 1100 North Glebe Rd., 8th Floor, Arlington, VA 22201-4714, telephone number (703) 816-4000 (to whom all communications are to be directed)**, and the following attorneys thereof (of the same address) individually and collectively my attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and with the resulting patent: Arthur R. Crawford, 25327; Larry S. Nixon, 25640; Robert A. Vanderhye, 27076; James T. Hosmer, 30184; Robert W Faris, 31352; Richard G. Besha, 22770; Mark E. Nusbaum, 32348; Michael J. Keenan, 32106; Bryan H. Davidson, 30251; Stanley C. Spooner, 27393; Leonard C. Mitchard, 29009; Duane M. Byers, 33363; Paul J. Henon, 33626; Jeffry H. Nelson, 30481; John R. Lastova, 33149; H. Warren Burnam, Jr. 29366; Thomas E. Byrne, 32205; Mary J. Wilson, 32955; J. Scott Davidson, 33489; Alan M. Kagen, 36178; William J. Griffin, 31260; Robert A. Molan, 29834; B. J. Sadoff, 36663; James D. Berquist, 34776; Updeep S. Gill, 37334.

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FOR ADDITIONAL INVENTORS, check box ☐ and attach sheet with same information and signature and date for each.